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Long-term clinical, technical, and esthetic outcomes of all-ceramic vs. titanium abutments on implant supporting single-tooth reconstructions after at least 5 years

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Abstract: AIM The aim of this prospective cohort study was to evaluate clinical, radiographic, technical, esthetic, and patient-centered outcomes of implants using two different restoration materials after 5-9 years. **MATERIALS AND METHODS** The study included 28 patients (test group: 13 patients with all-ceramic crowns on aluminum oxide-based abutments; control group: 15 patients with metal abutments on porcelain-fused-to-metal crowns). Evaluation of patient satisfaction, clinical (periodontal probing depth, bleeding on probing, plaque index, mucosal recession, and width of keratinized mucosa), esthetical (papilla index, clinical crown length), technical (loss of retention, marginal adaptation, chipping of ceramic, anatomical shape, occlusal wear, color match), and radiological parameters were assessed. The statistical analyses included comparison of all-ceramic vs. metal abutments and between the groups using Mann-Whitney U-tests. For esthetic parameters, changes over time were assessed using Friedman test and post hoc Wilcoxon test of all complete cases. **RESULTS** The survival rate of the restoration was 100% in both groups. Patient's satisfaction revealed 9.7 on the visual analog scale. A low satisfaction correlated with low ratings in color or anatomical shape. The mucosal recession in the test group was less than that in the control group. An increase in distal papilla height in the year 0 to 1, and a decrease from year 1 to 8, was detected. Sites, which received a soft tissue graft, revealed stable papillae over the observation period. Clinical crown length showed higher values in the control group. **CONCLUSIONS** Within the limitations of the study, it can be concluded that all-ceramic restorations reveal a high survival rate of 100% and show no difference to metal after a mean observation period of 7.2 years.

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Long-term clinical, technical and esthetic outcomes of all-ceramic vs. titanium abutments on implant supporting single tooth reconstructions after at least 5 years

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Abstract

Aim:

The aim of this prospective cohort study was to evaluate clinical, radiographic, technical, esthetic and patient centered outcomes of implants using two different restoration materials after 5 to 9 years.

Materials and Methods:

The study included 28 patients (test group: 13 patients with all-ceramic crowns on aluminum oxide–based abutments, control group 15 patients with metal abutments on PFM crowns). Evaluation of patient satisfaction, clinical (periodontal probing depths (PPD), bleeding on probing (BOP), plaque index (PI), mucosal recession (REC), and width of keratinized mucosa (KM)), esthetical (papilla index, clinical crown length (CCL)), technical (loss of retention, marginal adaptation, chipping of ceramic, anatomical shape, occlusal wear, color match) and radiological parameters were assessed. The statistical analyses included comparison of all-ceramic vs. metal abutments and between the groups using Mann-Whitney-U tests. For esthetic parameters, changes over time were assessed using Friedman test and post-hoc Wilcoxon test of all complete cases.

Results: The survival rate of the restoration was 100% in both groups. Patient's satisfaction revealed 9.7 on the VAS. A low satisfaction correlated with low ratings in color or anatomical shape. The mucosal recession in the test group was less than in the control group. An increase in distal papilla height in the year 0 to 1, and a decrease from year 1 to 8 was detected. Sites, which received a soft tissue graft revealed stable papillae over the observation period. Clinical crown length showed higher values in the control group.

Conclusions: Within the limitations of the study, it can be concluded that all-ceramic restorations reveal a high survival rate of 100% and show no difference to metal after a mean observation period of 7.2 years.

Introduction

Implants have been successfully used to replace missing teeth and show excellent **survival rates** after 5 and 10 years ([Jung, et al. 2012](#)). Since implants are in many cases the standard therapy to replace missing teeth, esthetic aspects have become more important. The main concern for the patient is therefore not only the function but also the esthetic outcome of the implant and its restoration.

Esthetics in implant dentistry has not only been focused on „white esthetics“ but more and more also on „pink esthetics“ ([Belser, et al. 2009](#), [Furhauser, et al. 2005](#)). This includes parameters like the presence or absence of the papillae, the emergence profile of the implant crown or the color of the soft tissue.

Basically two different material categories can be used as restorative materials for the reconstruction of an implant: metals or ceramics. Until today, titanium abutments are considered to be the ‘gold-standard’ for longevity of implant-borne reconstructions. A recent consensus report stated, that after a mean estimated observation period of 5 years, high survival rates for ceramic (99.1%) and metal (97.4%) abutments can be expected ([Hobkirk, et al. 2009](#)). In this systematic review all-ceramic crowns supported by ceramic abutments exhibited the same survival rates as metal-ceramic crowns supported by metal abutments. However, it has to be emphasized that only a very low number of ceramic abutments (n=166) have been compared to a large number of metal abutments (n=5683).

One major drawback of titanium abutments is that their **color** can cause a grayish discoloration of the peri-implant mucosa impairing the esthetic result of implant reconstructions ([Sailer, et al. 2009](#)).

Another study showed that the color of the peri-implant soft tissue matched that of the reference tooth in no more than just over one-third of cases, and showed major discrepancies in 20%. Hence, it might be speculated that tooth-colored ceramic abutments could play an important role in terms of color match ([Furhauser, Florescu, Benesch, Haas, Mailath & Watzek 2005](#)). A variety of studies have been initiated to evaluate the effect of the restorative material and the influence of the soft tissue thickness on the color of the peri-implant mucosa. ([Ishikawa-Nagai, et al. 2007](#), [Jung, et al. 2007](#), [Park, et al. 2007](#)). It has been documented, that a discoloration of the gingiva caused through a titanium abutment is not present with a minimum gingival width of at least 2mm ([Jung, et al. 2008](#)). In that clinical trial the increased soft tissue thickness was achieved by soft tissue grafting.

Today we still have limited evidence on the long-term outcome and the esthetic performance of all-ceramic reconstructions compared to titanium abutments with porcelain fused to metal reconstructions on implant-supported reconstructions.

Therefore, the aim of the present study is to evaluate the clinical, technical and esthetic outcomes of all-ceramic vs. titanium abutments on implant supporting single tooth reconstructions after an observation period of at least 5 years.

Materials and methods

Study design and original population

The present prospective cohort study included 28 out of 36 patients that were part of a former study identifying the effect of all-ceramic and porcelain-fused-to-metal (PFM) restorations on marginal peri-implant soft tissue color ([Jung, Holderegger, Sailer, Khraisat, Suter & Hammerle 2008](#)).

The treatment took place between 2002 and 2006 at the Department of Fixed and Removable Prosthodontics and Dental Material Science at the University of Zurich, Switzerland. For the present follow-up investigation, all patients were invited by an information letter to attend an appointment for a regular clinical and radiographic assessment. Only if patients did not answer, they were contacted by phone in order to set an appointment.

Treatment protocol / surgical procedure

Implant surgery followed standard surgical principles. The procedure was described in details in the previous investigation ([Jung, Holderegger, Sailer, Khraisat, Suter & Hammerle 2008](#)). In brief, after elevating a full thickness flap, the implant bed was prepared according to standard protocols and an implant (Straumann Dental Implant System, Straumann AG, Basel, Switzerland) was placed in the correct prosthetic position. Guided bone regeneration was performed when needed, using deproteinized bovine bone mineral and a collagen membrane (Bio-Oss®, Bio-Gide®, Geistlich AG, Wolhusen, Switzerland). Periosteal releasing incisions were then made to allow tension-free adaptation of the flap.

For postoperative care the patients received penicillin antibiotics (Amoxicillin 750 mg 1-1-1) for 6 days, painkiller if needed and rinsed with a 0.2%

chlorhexidine digluconate solution.

Suture removal has been taken place 7-10 days after implant surgery. Subsequently, the soft tissue thickness was evaluated using an endodontic needle. If the mucosal thickness was less than 2 mm a connective tissue graft was performed with the attempt to have similar mucosal thickness within all cases. In 14 out of 36 patients, a soft tissue grafting procedure was performed. After a healing period of 3 months the prosthetic phase has started and the patients were randomly assigned to either the test group (17 patients) or the control group (19 patients). The test group (all-ceramic group) received individualized Al₂O₃ abutments (synOcta In-Ceram blank, Straumann) and an all-ceramic restoration (alumina, Procera, Nobel Biocare). The all-ceramic restorations were either screw retained by directly veneering the all-ceramic abutment or cemented with resin cement (Panavia, Kuraray). In the control group (PFM group), each implant received a titanium (synOcta cementable abutment, Straumann) and a PFM restoration. The PFM restoration was either cemented with glass ionomer cement (Ketac Cem, 3M ESPE) or screw retained.

Follow-up examination

The last follow-up examination was performed at the Clinic for Fixed and Removable Prosthodontics and Dental Material Science, University of Zurich, Switzerland between the end of 2011 and 2012. Prior to the clinical and radiographic examination, information such as medical conditions, medications, smoking habits, self-reported biological and technical complications, and enrollment in a maintenance care program was collected. All implant restorations were photographed and a periapical radiograph was taken.

Evaluation of Patient Satisfaction

A visual analogue scale (VAS) was used to evaluate patient's overall satisfaction concerning the treatment, esthetics and function of the implants and the implant restorations. Before meeting the dentist, the visual analog scale was handed to the patient in order to rate the satisfaction on a scale from 0 to 10, where 10 indicated the highest level of satisfaction.

Clinical evaluation

The following clinical parameters were assessed at the implant site and at the adjacent mesial and distal tooth:

Biological evaluation included periodontal charting with probing pocket depth (PPD), bleeding on probing (BOP), presence of absence of plaque (PI), mucosal/gingival recession (REC), and the width of the keratinized mucosa (KM) at the buccal aspect. In addition, the implant survival was recorded.

Technical evaluation

Loss of retention due to abutment fracture, screw fracture or loosening and fracture of cement seal was recorded. The abutments and reconstructions were classified according to the modified United States Public Health Service (USPHS) criteria. The parameters evaluated were the marginal adaptation, chipping of the veneering ceramic, the anatomical shape, occlusal wear and the color match.

Esthetic evaluation

The height of the papillae was assessed at the mesial and distal site of the implant reconstruction and the neighboring teeth by means of a published index ([Jemt 1997](#)). This index describes five different levels indicating the amount of

papilla present in reference to the line through the highest gingival curvature of the restoration on the buccal side and the adjacent tooth and the contact point.

Clinical crown length (CCL)

The crown length was measured from the incisal edge to the highest gingival curvature of the implant crown. Changes over time have been assessed from the first year to baseline (1-0), from 8 years to baseline (8-0), and from 8 years to the first year follow-up after crown insertion.



Figure 1: Clinical crown length (CCL)

Radiographic analysis

For the evaluation of the distal and mesial marginal bone level, intraoral radiographs were taken. The X-rays were then digitalized with a scanner (Epson Perfection V750 Pro) and a resolution of 600 dpi for analyzing the marginal bone level (MBL). The marginal bone level is considered to be the distance between the top of the implant shoulder and the first visible bone-to-implant contact. It was measured at the mesial and distal using an image analysis program Image J64 (developed by the National Institutes of Health, USA). For calibrating the magnification and the distortion of the radiographs the measured distance between three implant threads was used ([Rodoni, et al.](#)

[2005](#)). All measurements were performed by two examiners and in case of disagreement discussed until an agreement was found.

Statistical analysis

The statistical analyses included comparison of the measurements taken between all-ceramic vs. metal abutments and between the groups with and without graft using Mann-Whitney-U tests. In addition, Mann-Whitney-U tests were applied to compare the marginal bone level between the implant types (Standard Plus versus Tapered Effect). For esthetic parameters, changes over time (baseline compared to 1 year and 8 years) were assessed using Friedman test and post-hoc Wilcoxon test of all complete cases. A p-value < 0.05 was considered significant.

Results

A total of 28 patients could be reassessed in the present study after a median observation period of 7.2 years (range 5.3 to 9.3 years), which represents 77.7% of the original study population consisting of 36 patients. 13 patients were women and 15 men. The median age at the time of reexamination was 48 years (range 27-82 years). 7 patients could not be examined. One patient died and 6 patients could not be reached for re-examination because of geographic reasons or severe illness. The same examiner examined all 28 patients. One additional patient could be reached for another study, which allowed assessing the USPHS criteria, but refused the radiological examination. Therefore, data of 29 patients of the USPHS criteria could be analyzed. 13 patients were part of the test group, 15 of the control group. In the test group 7 individuals needed a soft tissue grafting procedure, whereas in 6 patients the amount of soft tissue thickness was sufficient, measuring 2mm or more. In the control group, 6 patients needed a soft tissue grafting procedure, in 9 cases; the amount of soft tissue was sufficient.

Health questionnaire

In relation to the health questionnaire two patients had mental disorders, one patient osteoporosis, one patient a pituitary tumor, two patients high blood pressure and one patient neurodermatitis. Patient's history revealed that six individuals smoked.

Evaluation of Patient Satisfaction

The evaluation of the patient's overall satisfaction with the implant and the restoration revealed a mean value of 9.7 on the VAS scale from 0 to 10. 21 out of 28 patients that have rated the maximum score of 10 represented this high value. The ones that were not totally satisfied rated in between 8.2 and 9.0.

Clinical examination

The clinical measurements are listed in Table. 1

Probing pocket depth (PPD)

The mean probing depth of the test group was 3.87mm (SD 0.76), whereas in the control group 4.16mm (SD 1.19). Implants with a grafting procedure had probing depths of 4.09mm (SD 0.96), the group without graft 3.97mm (SD 1.07). There was no statistically significant difference between the groups.

Bleeding on probing (BOP)

In the test group a BOP of 45% (SD 25) was found, in the control group it mounted up to 56% (SD 31). When a soft tissue grafting procedure was performed, the BOP was 56% (SD 32) and in the group without graft 46% (SD 32) were found. There was no statistically significant difference between the groups.

Width of the keratinized mucosa

The mean width of keratinized mucosa on the buccal aspect was 3.72mm (SD 1.22) in the test group, whereas the control group was 3.04mm (SD 1.15). For the implants with grafting procedure 3.46mm (SD 1.12) and without grafting procedure 3.27mm (SD 1.32) was measured.

Recession

In the test group, in average no recession of the mucosal margin was detected. In contrast a slight increase of the soft tissue level could be seen with a mean of -0.31mm (SD 0.47). In the control group the mean recession of the buccal mucosal margin was 0.29mm (SD 0.47). In implants with grafting procedure the recession was reduced to -0.03mm (SD 0.66), and in the group without grafting procedure it was mounted to 0.06mm (SD 0.47). In the all-ceramic abutment group, the recession of the mucosa was statistically significant less than in the titanium group. Comparing the implants with or without graft, no such difference could be found.

	Abutment Group			Graft		
	Test	Control	Stat. Sign.	With Graft	No Graft	Stat. Sign.
n (missing)	16 (3)	20 (5)		14 (1)	22 (7)	
	Mean (SD)	Mean (SD)		Mean (SD)	Mean (SD)	
PPD (mm)	3.87 (0.76)	4.16 (1.19)	0.586	4.09 (0.96)	3.97 (1.07)	0.555
PI (%)	15 (29)	28 (31)	0.274	15 (32)	28 (28)	0.118
BOP (%)	45 (25)	56 (31)	0.339	56 (32)	46 (24)	0.339
KG (mm)	3.72 (1.22)	3.04 (1.15)	0.108	3.46 (1.12)	3.27 (1.32)	0.496
REC (mm)	-0.31 (0.47)	0.29 (0.47)	0.002*	-0.03 (0.66)	0.06 (0.47)	0.387

* significant

Table 1 clinical measurements at follow-up examination

Radiological examination

The radiographic outcome measurements are listed in Table 2

The radiographic evaluation demonstrated that all implants were osseointegrated. This is indicated by a visible direct contact between bone and implant.

The marginal bone level was analyzed according to implant type (Standard Plus versus Tapered Effect), abutment material and if a soft tissue grafting procedure was performed. No statistically significant difference was found between the groups.

Bone level	Abutment			Graft			Implant type		
	Test	Control	Stat. Sign.	Graft	No graft	Sign.	Standard Plus	Tapered effect	Stat. Sign.
n (missing)	16 (1)	20 (2)		14 (0)	22 (3)		26 (3)	10 (0)	
mesial	2.2 (0.7)	2.1 (0.9)	0.789	2.3 (0.7)	2.0 (0.9)	0.199	2.2 (0.8)	2.0 (0.8)	0.324
distal	2.8 (1.4)	2.4 (1.1)	0.464	2.7 (1.1)	2.4 (1.3)	0.255	2.8 (1.3)	2.0 (0.4)	0.089
mean	2.5 (0.9)	2.2 (0.9)	0.656	2.5 (0.8)	2.2 (0.9)	0.287	2.5 (1.0)	2.0 (0.5)	0.105

Table 2 radiographic outcome measurements

Technical evaluation

In none of the 28 cases a loss of retention could be detected, indicating that no fracture of an abutment or a screw loosening occurred. Therefore, the survival rate of the abutments and the crowns was 100% in both groups.

USPHS Criteria

USPHS criteria could be analyzed from 29 patients.

The marginal adaptation was in 19 patients rated as an A value, indicating a perfect adaptation of the crown. In 9 cases a crown margin that could be detected by the probe, was rated a B value. Chipping of the veneering ceramic occurred in 3 out of 29 patients. One major chipping occurred in the test group

with a loss of the veneering ceramic to the framework. In addition, 2 minor chippings occurred in the control group and could be polished. The chipping in the test group occurred at the mesial border and was not visible or disturbing for the patient.

A correct anatomical shape was detected in 21 patients, whereas 5 cases were rated as a B, and 3 as a C, indicating an under or over contoured crown or a missing contact point. In 28 patients, the occlusal wear was rated an A or B, meaning no or slightly wear at the reconstruction or the antagonistic tooth, only in one patient in the control group revealed a wear of more than 2mm in diameter. The color match of 28 of the reconstructions was scored A or B, only 3 crowns in the control group were considered as insufficient in color match, and therefore rated as a C.

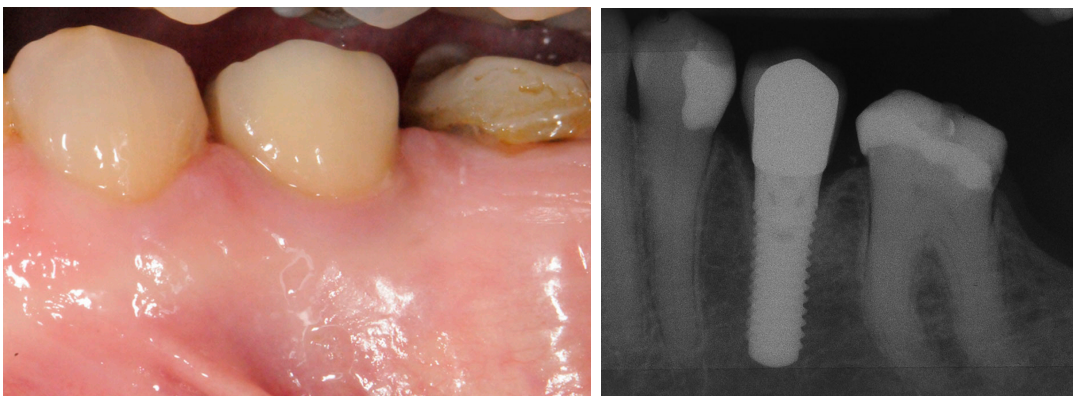


Figure 2: Patient No. 103 without contact point after 8.4years

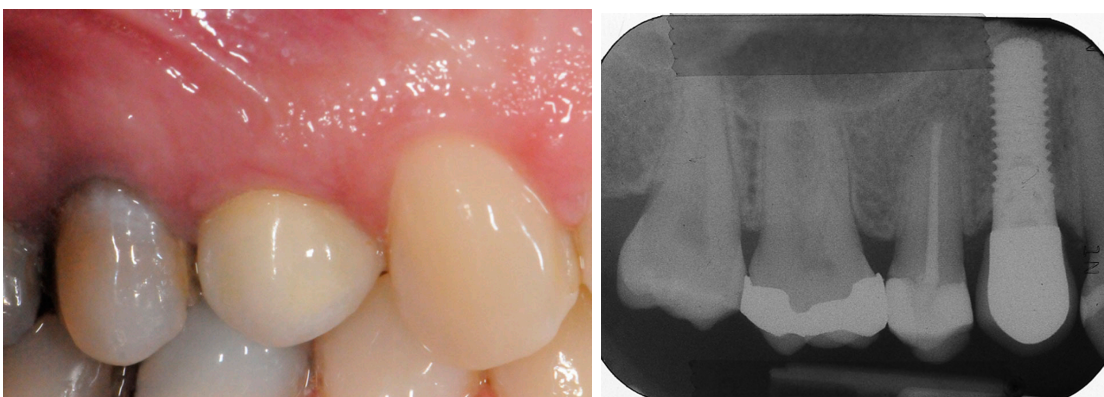


Figure 3: Patient No. 123 showed an insufficient color match with neighboring teeth after 7.0years

		Total	Abutment	
			Test	Control
No:		29	13	16
Marginal adaptation				
	A	19	9	10
	B	9	4	5
	C			
	D			
Chipping of the veneering ceramic				
	A	26	12	14
	B	2		2
	C	1	1	
	D			
Anatomical shape				
	A	21	10	11
	B	5	3	2
	C	3		3
	D			
Occlusal wear				
	A	18	8	10
	B	10	5	5
	C	1	0	1
	D			
Color				
	A	10	5	5
	B	16	8	8
	C	3		3
	D			

Table 3: USPHS Criteria for all cases and for control and test abutment

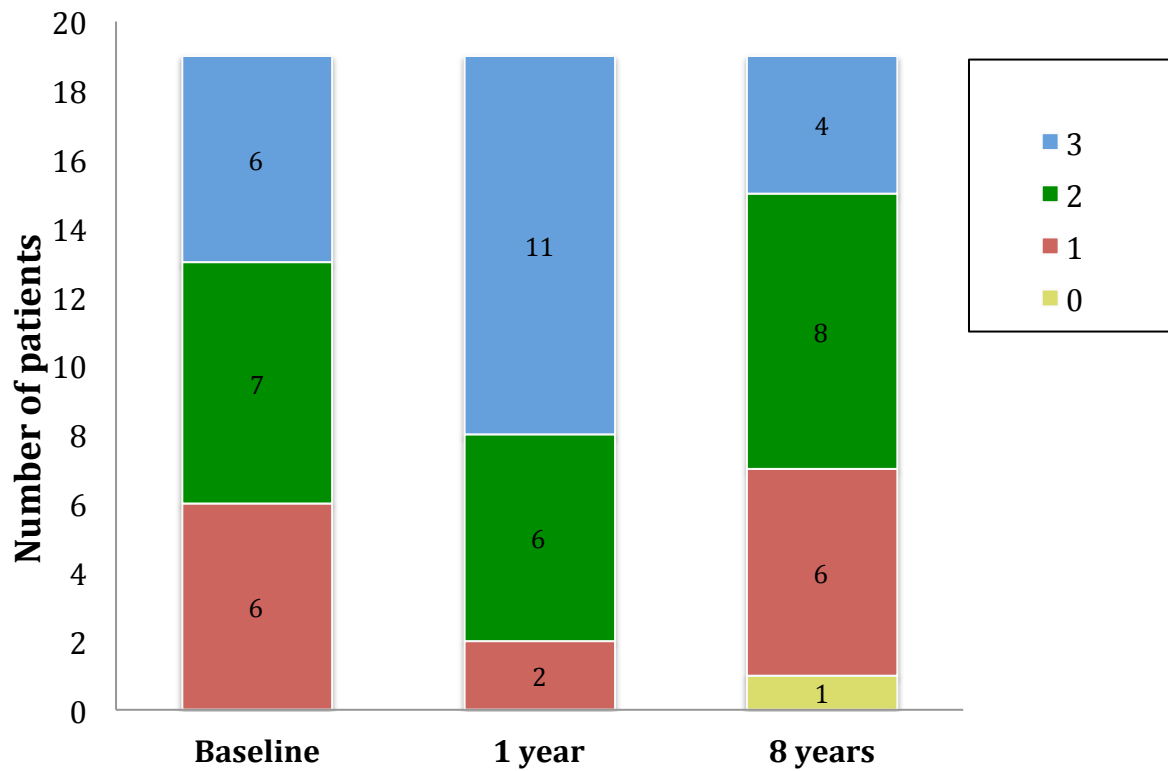
Esthetic evaluation

For the esthetic evaluation the papilla height index ([Jemt 1997](#)) and the changes of the clinical crown length have been assessed and depicted in table 4-7.

Jemt Index

Taking the complete cases of the entire study population into account, a statistical significant increase in distal papilla height in the year 0 to 1 ($p=0.007$), and a statistical significant decrease from year 1 to 8 ($p=0.005$) was detected. Therefore, the distal papilla height after insertion of the crown was similar at baseline and after 8 years ($p=0.47$). In contrast, the sites, which received a soft tissue graft before crown insertion revealed stable papilla heights over the entire observation period without any statistical significant differences ($p>0.05$), neither for the distal nor for mesial sites. This points out that the changes of papilla height was mainly true for the sites without soft tissue grafting, for mesial and distal, compared to the sites receiving a soft tissue graft. In the mesial papilla no difference over time and comparing with and without soft tissue grafts could be found (all $p>0.05$). In addition, no difference over time could be detected between the two abutment material groups (all $p>0.05$).

JEMT distal complete cases (n=19)



JEMT mesial complete cases (n=19)

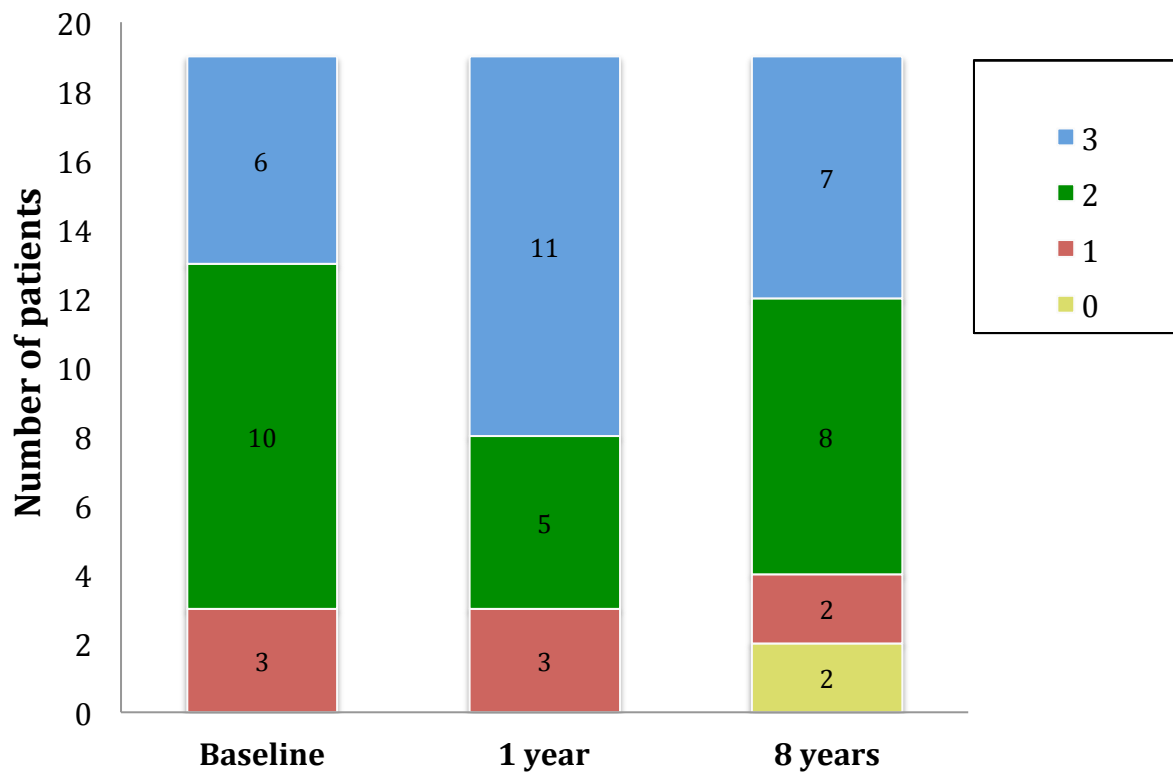


Figure 4 and 5: Jemt Index of complete cases (n=19) over time of mesial and distal papillae

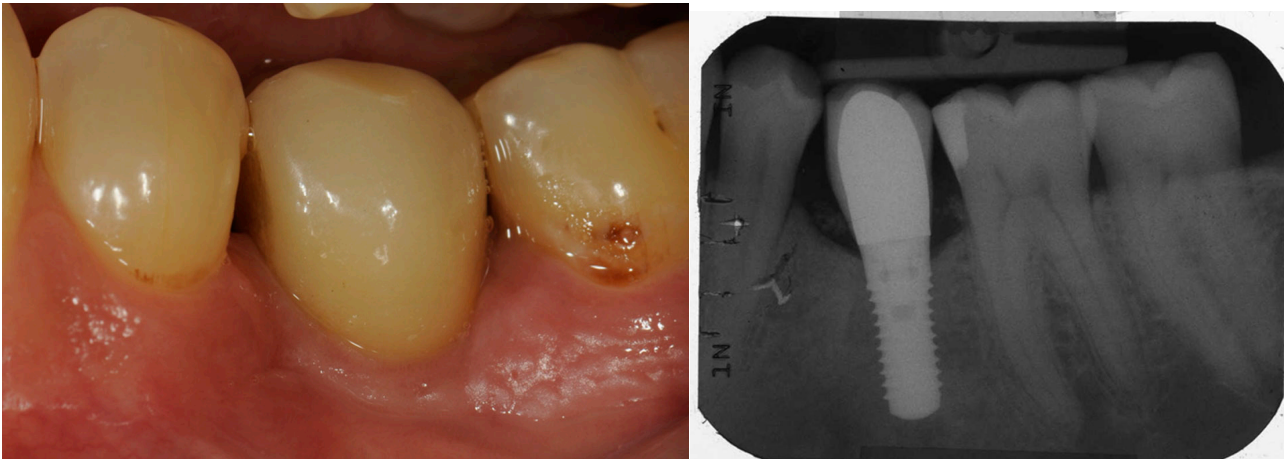


Figure 6: Patient No. 132 papilla height after 9.3years

Clinical crown length (CCL)

The change in the clinical crown length, measuring the distance from the incisal edge to the zenith of the gingival curvature, showed a significant change over time. This change could already be detected after one year. For the different abutment materials in complete cases, significant differences could be found, with a longer crown length in the control group.

	Abutment Test Mean (SD), <i>Median</i>	Abutment Control Mean (SD), <i>Median</i>	With Graft Mean (SD), <i>Median</i>	Without Graft Mean (SD), <i>Median</i>
Year 0	10.44 (1.34), <i>11.0</i> n= 16	9.16 (2.05), <i>9.0</i> n=19	10.54 (1.39), <i>11.0</i> n= 13	9.27 (1.96), <i>9.0</i> n= 22
Stat. signif.	0.009		0.159	

Year 1	10.67 (1.60), 11.0 n= 12	9.37 (2.09), 9.0 n= 15	10.67 (1.48), 11.0 n= 9	9.58 (2.12), 9.0 n= 18
Stat. signif	0.023		0.194	
Year 8	10.54 (1.51), 11.0 n= 13	9.53 (2.42), 9.0 n= 15	11.23 (1.92), 12.0 n= 13	8.93 (1.58), 9.0 n= 15
Stat. signif	0.063		0.03	
Diff. 1-0	0.29 (1.42), 0.0	0.47 (0.79), 0.0	0.50 (0.66), 0.5	0.33 (1.27), 0.0
Stat. signif	0.738		0.463	
Diff. 8-0	0.19 (0.72), 0.0	0.86 (1.17), 0.5	0.92 (1.2), 0.5	0.23 (0.75), 0.0
Stat. signif.	0.315		0.152	

Table 4: Clinical crown length divided in groups abutments / grafts, differences in time points (year 1-0, 8-0) and statistical differences between groups.

For the statistical analysis of differences in time points (year 1-0, 8-0), only complete cases were included (n = 20).

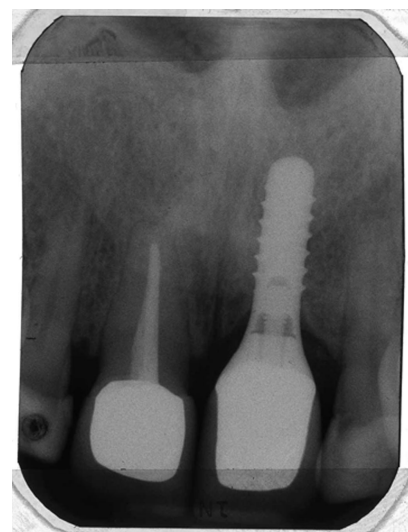


Figure 7: Patient No. 102 clinical crown length after 6.7years

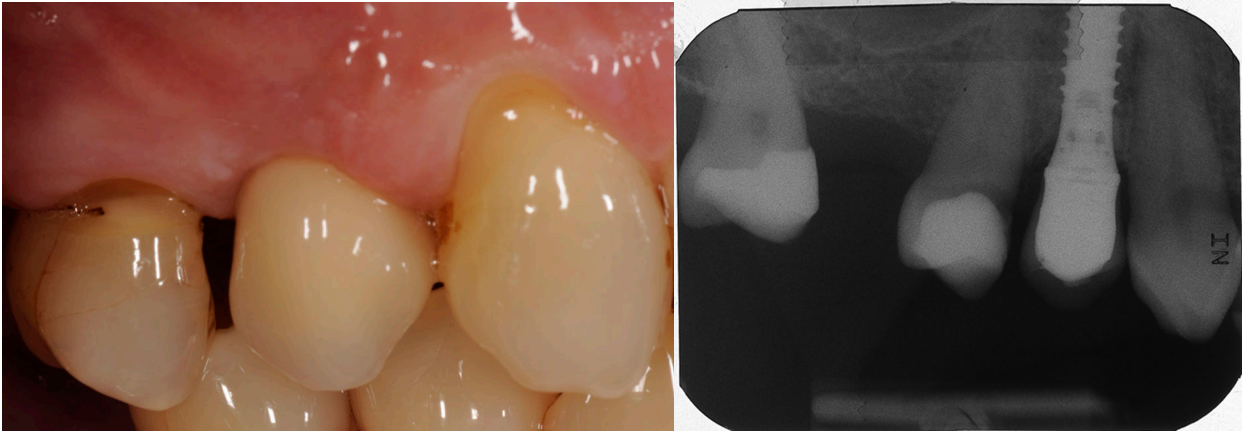


Figure 8: Patient No. 131 with all-ceramic reconstruction without soft tissue grafting procedure after 8.5years.



Figure 9: Patient No. 116 with all-ceramic reconstruction and soft tissue grafting procedure after 9.3years

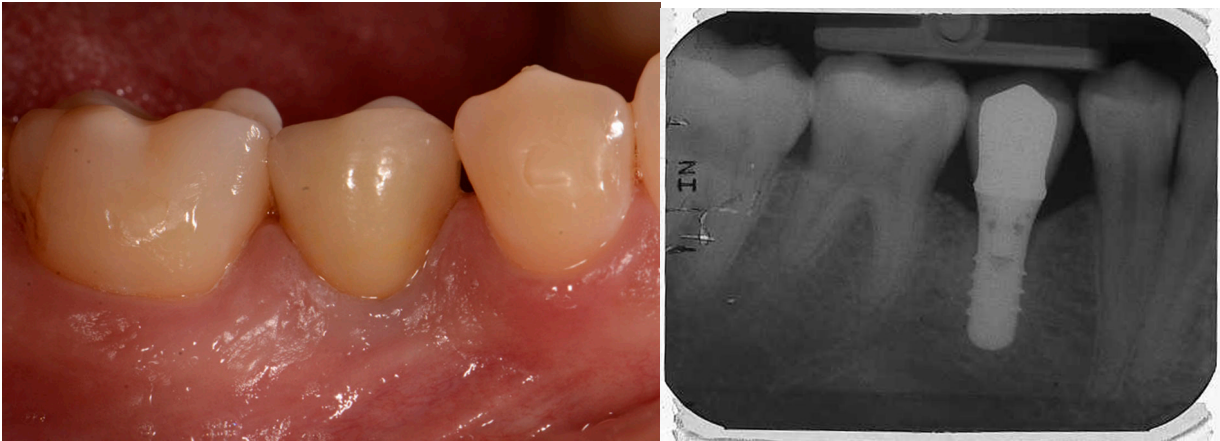


Figure 10: Patient No. 134 with PFM reconstruction without soft tissue grafting procedure after 8.2years



Figure 11: Patient 129 with PFM reconstruction and soft tissue grafting procedure after 5.9years

Discussion

The present prospective cohort clinical trial demonstrated that there is no difference between all-ceramic and titanium abutments in regard to clinical, radiographic and technical outcomes after a mean observation period of 7.2 years.

For the reexamination a high number of patients could be reached, so that the recall rate reached 77.7% of the original patient population.

Within the present study a very high **survival rate** of the implants and the single tooth reconstructions of 100% could be found after a mean observation period ranging from 5.3 to 9.3 years. This is in agreement or slightly higher compared to previously published systematic reviews revealing a implant survival rate of 97.2% (Jung et al 2012). For ceramic abutments an estimated 5-year survival rate of 99.1% could be found, for metal abutments, the rate was slightly lower with 97.4% ([Sailer, Philipp, Zembic, Pjetursson, Hammerle & Zwahlen 2009](#)). Nevertheless, in one study including alumina and titanium abutments for single-implant crowns, a 6.7% fracture rate of the alumina abutments was reported ([Andersson, et al. 2001](#)).

The high survival rate of the present study can be explained by the fact that a small and well-controlled population was included. The implant sites represented standard clinical procedures with single unit reconstructions. However, we have to be aware that it is still unknown whether the survival rate of all-ceramic abutments compared to titanium remains stable or whether we have to expect a clinically relevant degradation of the ceramic material over time. An in vitro study showed a 50% decrease of the fracture toughness of zirconia during a simulated 10-year aging process in a humid environment

([Studart, et al. 2007](#)). There are no data available for the long-term aging process of alumina abutments used in the present study. In today's clinical practice alumina has mainly been replaced by zirconia because of higher material stability either for abutments and/or crowns. For zirconia abutments there is a very recent clinical study reporting on long-term data ([Zembic, et al. 2014](#)). After an observation period of 11 years the cumulative success rate was 96.3% for abutments and 90.7% for crowns.

The present study demonstrated a mean overall **satisfaction** of 97% with a range from 82 – 100% after 7.2 years. This high overall patient's satisfaction is in accordance with a previous clinical study also assessing esthetic satisfaction of the patients using a visual analogue scale (VAS). They reported on a median VAS value of 96% (range 70-100%) even though the implant crown in comparison to the natural control tooth was longer, had a smaller bucco-lingual width and had a lower height of the distal papilla ([Chang, et al. 1999](#)).

Interestingly a correlation between the patient's satisfaction and the evaluated anatomical shape as well as the color of the restoration could be found in the present study. A low patient's satisfaction correlated with an insufficient rating in color match (rating C) and an insufficient anatomical shape like an over or under contoured crown or a missing contact point. In cases where the shape and the color are rated A or B, the satisfaction of the patient was higher. In the all-ceramic group, the color match seem to be favorable, since there was no rating C, compared to the titanium group with 18.8% of C (3 out of 16).

In regard to the mucosal margin, the present study revealed significantly less mucosal **recession** in the all-ceramic group of -0.31mm (SD 0.47) compared to the titanium group (0.29mm (SD 0.47)). In a very recent clinical study zirconia abutments have been evaluated over an observation period of 11 years. It was reported that the all-ceramic abutments revealed an excellent biologic

integration by only 0.2mm (SD 1.1) of mucosal recession ([Zembic, Philipp, Hammerle, Wohlwend & Sailer 2014](#)). However, in another clinical trial, all-ceramic abutments made of Alumina revealed slightly more recessions after an observation period of 2 years, without statistical significance difference compared to titanium abutments with PFM crowns ([Gallucci, et al. 2011](#)).

Considering preclinical studies, it was demonstrated by different dog trials that there was no difference between all-ceramic and titanium abutments in regard to mucosal stability ([Abrahamsson, et al. 1998](#)),([Welander, et al. 2008](#)).

In respect to the **esthetic outcome**, the soft tissue stability has been considered an important factor for esthetic success ([Belser, et al. 2004](#)). Especially the papillae and the mucosal margin play an important role. A previous clinical study documented an increased papilla height after a mean follow-up period of 1.5 years after prosthetic loading ([Jemt 1997](#)). There is little data available on the changes of the papilla height over longer time periods. In a retrospective study, a photographic evaluation of implants after 1 to 9 years (mean 3.5 years) stated, that papillae regenerated in 83.9% of implants, with a mean growth of 0.65mm mesially and 0.62mm distally ([Priest 2003](#)). In contrast, the present study revealed an increase in papilla height from baseline to the first year, and a decrease from the first year to the 8-year follow-up. Therefore, the initial papilla height after insertion of the crown was similar in the beginning and after 8 years. The clinical impact of this finding shows, that the prosthetic design and the emergence profile might already be defined at the time of crown insertion. This is based on the clinical results of the present study, indicating a decrease of the papilla between year one and year 8, coming back to the original level at crown insertion. In contrast, cases treated with connective tissue graft presented a more stable papilla height after an observation time of 8 years.

Within the **limitation** of this study, where only a small group of 36 patients were treated, the results have to be interpreted with caution. For the careful evaluation of material properties more long-term studies with larger population have to be designed. The positive effect of the soft tissue grafting procedure on the papilla is present, but it has to be kept in mind, that these results are based on a small number of eight patients compared to 12 patients without soft tissue grafting procedures, compared to 12 patients without soft tissue grafting procedures. Concerning the measurements of the recessions, it is difficult to reproduce exact values. In a tooth, the cement – enamel – junction is clearly visible, and a recession can be measured in a standardized way. In implants supporting screw-retained crowns, this natural border is not present. Therefore, it is sometimes unclear from which point to measure the recessions. One reproducible way is to measure the clinical crown length, measured from the incisal edge to the most apical part of the mucosa. This value is more reproducible, because the CCL depends on the margin of the soft tissue.

Conclusions

Within the limitations of the present study, it can be concluded that all-ceramic restorations made of alumina reveal a high survival rate of 100% and show no difference to metal abutments with PFM crowns after a mean observation period of 7.2 years.

In addition, the CCL remained stable with changes below 1mm and the papilla height increases from crown insertion to the first year, but decreases to the eight year follow up to the level at crown insertion.

Acknowledgements and conflict of interest

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